



Green surgery: to reduce carbon footprint

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Environmental, economic, and ethical considerations have come together to make green surgery a need in hospitals. Because of their operations, healthcare institutions have the potential to significantly impact the environment through their use of energy, trash production, and resource depletion. An effort to lessen these effects has been the rise of 'green surgery' programs, which seek to reduce surgical waste without sacrificing the quality of care for patients^[1]. Green surgery has real advantages beyond just helping the environment. For example, patients can save money on energy and garbage by having less surgical procedures done. Hospitals are also under growing pressure to conform to rules and regulations, as environmental sustainability is being prioritized by regulatory bodies. Corporate social responsibility goals and a hospital's image as an eco-friendly leader are both served by green surgery. The ultimate goal of implementing green surgery practices is to ensure the health and safety of patients and the community at large in the long run. The term 'green surgery' is most commonly used to describe surgical procedures that are designed to be as gentle on the environment as possible and as sustainable as possible^[2]. Some examples of these methods include making less use of energy, producing less trash, and utilizing eco-friendly tools and materials. Reducing the use of disposable products, recycling, improving surgical methods to limit resource consumption, and implementing eco-friendly anesthetic practices are all possible steps in green surgery projects^[3]. While preserving excellent patient care and safety, the objective is to lessen the environmental impact of surgical procedures. In addition to contributing to climate change, halogenated anesthetic gases like isoflurane and nitrous oxide deplete the ozone layer, which in turn reduces the atmosphere's protective effect against ultraviolet radiation and increases the likelihood of skin cancer in areas where this occurs^[4]. It is believed that 2.8% of the world's

particulate matter (PM₁₀) emissions and 3.4–3.6% of the air pollutants sulfur dioxide and nitrogen oxides come from the healthcare industry^[5].

Toxicological, physiological, or chemical impacts on ecosystems caused by human activity are collectively known as ecotoxicity. Bioactive pharmaceutical chemicals, such as antibiotics, analgesics, and anti-inflammatory medications, are found in higher amounts in water systems and soil as a result of pharmaceutical use and disposal^[6]. Bioaccumulation occurs when other species, such as birds, reptiles, and fish, ingest pharmaceutical residues at a rate higher than their clearance rate^[6]. There is a 6.1% annual growth rate in the worldwide medical plastics industry, which accounts for 2% of total plastics production by value, and the usage of single-use plastics is becoming more prevalent in healthcare^[7]. This adds to the buildup of plastic debris in our biosphere and, via the combustion of fossil fuels in industrial processes, to the problem of global warming^[8]. Additionally, there is evidence of elevated microplastic levels in the operating room, which might be attributed to the extensive usage of plastic items there^[9]. Emerging research suggests that some microplastics and their additives can produce cytotoxicity, hypersensitivity, immunotoxicity, and endocrine disruption; however, the exact extent to which this exposure could impact staff or patients' health is still unknown^[10].

By following the principles of the circular economy, surgical products can have less of an impact on the environment. This includes reducing the number of items used in each procedure, making better use of personal protective equipment, and, when possible, replacing single-use items with reusable ones. When 'reduce and reuse' isn't an option, repairing and remanufacturing products and recycling trash can help them last longer. The operating room personnel can save energy use by turning off or turning down unneeded equipment. The use of shutdown checklists, energy-efficient lighting and appliances, and clinically appropriate ventilation systems with lower energy consumption and appropriate setback modes are all potential retrofits that can be incorporated into operating theater designs. Motion sensors for lighting are another potential addition. Renewable energy may be used and ideally generated by hospitals.

One major contributor to global warming is anesthetic gases, especially desflurane, which is now being phased out by the National Health Service (NHS)^[11]. More eco-friendly alternatives, such as intravenous, regional, or local anesthesia, can reduce volatile anesthetic emissions. Decommissioning centrally piped nitrous oxide and replacing it with portable cylinders can reduce emissions. The majority of energy consumption in anesthetic equipment is caused by Anaesthetic Gas Scavenging Systems (AGSS)^[12], which are often running even when theaters are not in use^[13]. AGSS can be turned off while the operating room is not in use or in cases when procedures like TIVA (total intravenous anesthesia), regional anesthesia, or simply intravenous sedation are employed, which are all controlled by switches.

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It is important to have proper safety mechanisms and SOPs (standard operating procedures) in place to turn AGSS back on when needed. To evaluate the carbon and cost savings linked to turning off AGSS, an open-source tool has been created^[14]. In order to keep the operating room at a comfortable temperature, humidity level, and free of airborne contaminants, advanced ventilation systems are needed. The majority of the airborne contaminants in the operating room come from the ~10 000 skin particles that staff members shed every minute^[15]. However, there are a number of factors that affect the probability of acquiring a surgical site infection; the most important of these are the patient's health status and the type of surgery^[16]. Reducing energy emissions is an important task that healthcare workers can accomplish. Operating rooms, pathology labs, and other energy-intensive and labor-intensive areas can benefit from a more structured approach that includes a shutdown checklist that provides detailed instructions to staff on what to turn off when the facility is not in use, including, if feasible, the AGSS in the theater suite. This checklist should also include safety protocols and a 'turn on' checklist. There may be monetary savings associated with this strategy. Turning off anesthetic machines and operating room lights when they weren't in use resulted in a \$33 000 savings and 343 metric tons of CO₂ reductions annually in one American setting^[17]. If placed and set up correctly, automation employing passive infrared (PIR) sensors to regulate lighting, airflow, and temperature may also assist in cutting down on energy usage and do away with human mistakes [by, for instance, making sure the HVAC (Heating, Ventilation, and Air Conditioning) system is on while theaters are in use]. As an additional tool for measurement and modification, submetering and dashboards for staff input might be useful.

An essential topic for future study is the importance of surgical illness prevention, the reduction of unnecessary variation, and the elimination of low-value treatment (making sure the carbon load associated with surgery is required rather than avoidable). The digitization of surgical care is still in its early stages, and models should account for the increasing concern about data centers' water and carbon footprints. It is crucial to thoroughly assess the potential risks of artificial intelligence (AI) in healthcare settings, such as overdiagnosis and the resulting excessive use of healthcare resources and carbon emissions. Equal access to sustainable surgical care may be achieved through research that examines the most effective ways to implement treatments on a national level, considering various locations such as metropolitan, inner-city, rural, and coastal hospitals. The expected rise in the usage of reusable equipment necessitates an assessment of the present and future requirements of reprocessing facilities, such as those for decontamination, sterilization, washing, and repair sites. There needs to be a consensus on how these assessments should be conducted and reported in order to improve their validity and reliability for informing policy and purchasing decisions. Currently, there is a lot of variation in how these assessments are carried out and reported for healthcare products, as well as methodological issues with some of the published studies. Other mitigating options, such as digital or remote care, also require better ways to measure their environmental impact^[18]. The surgical sector should prepare for this by creating reusable devices and other solutions that contribute to the objective of net zero surgery. Servitization and other alternative buying patterns that might facilitate such a shift should also be thoroughly investigated.

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References

- [1] Piotet LM, Mantziari S, Uldry E, *et al.* Surgery sustainability in surgical practice: the “green surgery” concept and its innovations. *Rev Med Suisse* 2022;18:152–5.
- [2] Kwakye G, Brat GA, Makary MA. Green surgical practices for health care. *Arch Surg* 2011;146:131–6.
- [3] Pietrabissa A, Sylla P. Green surgery: time to make a choice. *Surg Endosc* 2023;37:6609–10.
- [4] Varughese S, Ahmed R. Environmental and occupational considerations of anesthesia: a narrative review and update. *Anesth Analg* 2021;133: 826–35.
- [5] Lenzen M, Malik A, Li M, *et al.* The environmental footprint of health care: a global assessment. *Lancet Planet Heal* 2020;4:E271–9.
- [6] Puckowski A, Mioduszevska K, Łukaszewicz P, *et al.* Bioaccumulation and analytics of pharmaceutical residues in the environment: a review. *J Pharm Biomed Anal* 2016;127:232–55.
- [7] Grand View Research. Medical Plastics Market Size, Share & Growth Report, 2030. Accessed 21 May 2024. <https://www.grandviewresearch.com/industry-analysis/medical-plastics-market>
- [8] Thompson RC, Moore CJ, vom Saal FS, *et al.* Plastics, the environment and human health: current consensus and future trends. *Philos Trans R Soc B Biol Sci* 2009;364:2153–66.

- [9] Field DT, Green JL, Bennett R, *et al.* Microplastics in the surgical environment. *Environ Int* 2022;170:107630.
- [10] Campanale C, Massarelli C, Savino I, *et al.* A detailed review study on potential effects of microplastics and additives of concern on human health. *Int J Environ Res Public Health* 2020;17:1212.
- [11] NHS England. Greener NHS » NHS organisations cut desflurane in drive for greener surgery. Accessed 21 May 2024. <https://www.england.nhs.uk/greenernhs/whats-already-happening/nhs-organisations-cut-desflurane-in-drive-for-greener-surgery/>
- [12] UCL Discovery. Understanding hospital electricity use: an end-use(r) perspective - UCL Discovery. Accessed 21 May 2024. <https://discovery.ucl.ac.uk/id/eprint/1514500/>
- [13] Pierce T, Morris G, Parker B. Reducing theatre energy consumption. *Health Estate* 2014;68:58–62.
- [14] Centre for Sustainable Healthcare. The Anaesthetic Gas Scavenging System (AGSS) Project | Centre for Sustainable Healthcare. Accessed 21 May 2024. <https://sustainablehealthcare.org.uk/what-we-do/sustainable-specialties/anaesthetics/anaesthetic-gas-scavenging-system>
- [15] Ritter MA. Operating room environment. *Clin Orthop Relat Res* 1999:103–9.
- [16] Alfonso-Sanchez JL, Martinez IM, Martín-Moreno JM, *et al.* Analyzing the risk factors influencing surgical site infections: the site of environmental factors. *Can J Surg* 2017;60:155–61.
- [17] Wormer BA, Augenstein VA, Carpenter CL, *et al.* The green operating room: simple changes to reduce cost and our carbon footprint. *Am Surg* 2013;79:666–71.
- [18] Lokmic-Tomkins Z, Davies S, Block LJ, *et al.* Assessing the carbon footprint of digital health interventions: a scoping review. *J Am Med Inform Assoc* 2022;29:2128–39.